Percent Within Limits (PWL) Determinations

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Discussion Outline

- What are the acceptance criteria?

- What are the payment criteria?

- What are common problems and how do they affect payment?

- PWL & lots example for P-501 concrete

$50,000 per hour

Small oversights in acceptance and payment determination result in BIG dollars.

P-501 Acceptability Criteria

Three sets of criteria to observe, monitor, and document:

1. Field Acceptability Criteria

   - Slump

   - Air Content

   - Temperature(s)

P-501 Acceptability Criteria

Three sets of criteria to observe, monitor, and document:

2. Acceptance Criteria

- Smoothness
- Grade
- Edge Slump
- Dowel Bar Alignment
- Cracking

P-501 Acceptability Criteria

Three sets of criteria to observe, monitor, and document:

   3. Payment Criteria

- Flexural Strength
- Depth / Thickness

P-501 Field Acceptability Criteria

- Slump
  - One point falls outside +0.5″ to -1.5″ (suspension)
  - Two points fall outside +0″ to -1″ (action)
- Air Content
  - One point falls outside +/- 1.8% (suspension)
  - Two points fall outside +/- 1.2% (action)

P-501 Field Acceptability Criteria

- Temperature
  - Cold-weather ops:
    - 40°F Ground Temperature (usually should be 40°F or higher for a few days prior)
    - 35°F Air Temperature and rising when placed
    - Keep at 50°F while curing
  - Hot weather ops:
    - Use ice or chill mix water
    - Can use hydrogen cooling for slip formed work
  - Curing compound required

P-501 Acceptance Criteria

- Smoothness
  - 16′ straightedge, ¼″ deviation
  - ¼″ to ½″ deviation can be corrected with grinding
  - Greater than ½″ = rejection
- Grade(s)
  - 0.10′ maximum lateral deviation
  - 0.04′ maximum vertical deviation

P-501 Acceptance Criteria

- Edge Slump
  - Per 500′ section of <u>Free Edge</u>
  - Not more than 15% greater than ¼″ slump
  - 3/8″ = rejection
- Dowel Bar Alignment
  - Not more than 2% (1/4″ per foot) off of true
- Cracking / Spalling / Repairs
- Deviation from any of these ***is*** cause for rejection and must be documented and noted in testing reports

Flexural Strength = Beams

- P-501 calls for testing beams rather than cylinders

- 4 Sublots with 2 beams each = Eight 28-day beams minimum

- Beams are high maintenance:
  - Don't move for 24 hours
  - Don't bounce in back of a truck
  - Store & cure in water baths or field-cure in sand
  - Finished/protected same as slab (i.e. covered in cold weather

P-501 Payment Criteria

So – Once the Pavement is Acceptable, how much is it worth?

- Worth the sum of the parts / Paid per Lot
- Based on:
  - Flexural Strength
    - PWL of 90 or better
    - 4 sublots with 2 beams each
    - Eight 28-day beams minimum
  - Thickness
    - Lower limit to be within 0.5″ of plan thickness. No upper limit.
    - Mod to Standard: May define Upper Limit.
    - 4 sublots, one core per sublot

P-501 Payment Criteria Issues

Murphy loves construction projects. What happens when you "lose" a beam or core?

- Improper / Broken Beams:

- Equipment malfunctions:
  - Batch plant / Pump truck / Paver breaks down
  - Formwork breaks

- Rejected concrete

All of these result in missing or incomplete data sets for a lot, which could impact pay to the Contractor if not handled appropriately.

P-501 Payment Example

So how do you deal with incomplete lots and determine contractor pay?

- Example: FAA Municipal Airport
    - 1,000 sy Apron Expansion
    - Two lots / Two days work planned
    - Specification
        - 650 psi Flex
        - 2″ Slump
        - 8.0″ PCC
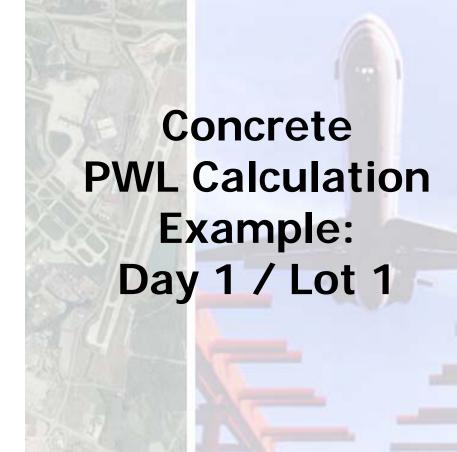   - Contractor to use concrete pump truck to place
        - Any problems?

AIRPORT: FAA Muncipial Airport
AIP NUMBER: 3-40-0000-006-2008

SUMMARY: CONCRETE TEST RESULTS

DATE: 10/31/2008   LOT NO.   1
TYPE: P-501

Flex Strength= 650   Depth= 8.0

Sublot #	28-Day	Average		Core Length	
1a	650			8.0	
1b	670	660			
2a	670			8.2	
2b	690	680			
3a	730			8.1	
3b	710	720			
4a	730			8.4	
4b	750	740			
5a					
5b					
6a					
6b					
AVG (x):		700		8.2	
$d1^2$	1600.0000			0.0306	
$d2^2$	400.0000			0.0006	
$d3^2$	400.0000			0.0056	
$d4^2$	1600.0000			0.0506	
$d5^2$					
$d6^2$					
Sn=	36.5148			0.1708	
	QL	QU		QL	QU
QI=	1.3693			1.0247	
N=	4			N=	4
PWL=	95	100%		84	97%
Total Pay =	99%				

Concrete PWL Calculation Example: Day 1 / Lot 1

AIRPORT: FAA Muncipial Airport
AIP NUMBER: 3-40-0000-006-2008

SUMMARY: CONCRETE TEST RESULTS

DATE: 10/31/2008   LOT NO.   2
TYPE: P-501

Flex Strength= 650   Depth= 8.0

Sublot #	28-Day	Average	Core Length	
1a	650		8.1	
1b	670	660		
2a	660		8.2	
2b	680	670		
3a				
3b				
4a				
4b				
5a				
5b				
6a				
6b				
AVG (x):		665	8.2	
$d1^2$	25.0000		0.0025	
$d2^2$	25.0000		0.0025	
$d3^2$				
$d4^2$				
$d5^2$				
$d6^2$				
Sn=	7.0711		0.0707	
	QL	QU	QL	QU
QI=	2.1213		2.1213	
N=	2		N=	2
PWL=				
Total Pay =	0%			

Concrete PWL Calculation Example: Day 2 / Lot 2

Concrete Pump Truck Breaks Down halfway through the lot.

What Happens to the Lot PWL Calculation?

AIRPORT: FAA Muncipial Airport
AIP NUMBER: 3-40-0000-006-2008

SUMMARY: CONCRETE TEST RESULTS

DATE: 10/31/2008   LOT NO.   3
TYPE: P-501

Flex Strength= 650   Depth= 8.0

Sublot #	28-Day	Average	Core Length	
1a	660		8.0	
1b	680	670		
2a	680		8.2	
2b	700	690		
3a	740		8.1	
3b	720	730		
4a	740		8.4	
4b	760	750		
5a				
5b				
6a				
6b				
AVG (x):		710	8.2	
$d1^2$	1600.0000		0.0306	
$d2^2$	400.0000		0.0006	
$d3^2$	400.0000		0.0056	
$d4^2$	1600.0000		0.0506	
$d5^2$				
$d6^2$				
Sn=	36.5148		0.1708	
	QL	QU	QL	QU
QI=	1.6432		1.0247	
N=	4		N=	4
PWL=	100	106%	84	97%
Total Pay =	103%			

Concrete PWL Calculation Example: Day 3 / Lot 3

Even though this is the rest of Lot 2, it counts as a new lot – one day's production.

AIRPORT: FAA Muncipial Airport
AIP NUMBER: 3-40-0000-006-2008

SUMMARY: CONCRETE TEST RESULTS

DATE: 10/31/2008   LOT NO.   2&3
TYPE: P-501

Flex Strength= 650   Depth= 8.0

Sublot #	28-Day	Average	Core Length	
3-1a	660		8.0	
3-1b	680	670		
3-2a	680		8.2	
3-2b	700	690		
3-3a	740		8.1	
3-3b	720	730		
3-4a	740		8.4	
3-4b	760	750		
2-1a	650		8.1	
2-1b	670	660		
2-2a	660		8.2	
2-2b	680	670		
AVG (x):		695.0	8.2	
$d1^2$	625.0000		0.0278	
$d2^2$	25.0000		0.0011	
$d3^2$	1225.0000		0.0044	
$d4^2$	3025.0000		0.0544	
$d5^2$	1225.0000		0.0044	
$d6^2$	625.0000		0.0011	
Sn=	36.7423		0.1366	
	QL	QU	QL	QU
QI=	1.2247		1.2199	
N=	6		N=	6
PWL=	89	100%	89	100%
Total Pay =	100%			

Concrete PWL Calculation Example: Lot 2 & 3

Per P501-5.1, partial lots of 2 or fewer sublots shall be combined with another full lot.

Ed:
Class exercise will be like this:

• Have "class" calculate the sublot and lot averages for strength and thickness for Lot 1

• Provide the standard deviation values (d^2 and Sn) and Quality Index (Q)

• Look up in chart the PWL and determine pay factor for strength and thickness

• Calculate total Lot pay factor.

• Lot 2: Have class determine what to do – calculate or not calculate

• Lot 3: Have class determine what to do – calculate or not calculate

• Discuss Lot 2 &3 and show answer.

Concrete PWL Calculation Example

TABLE 1. TABLE FOR ESTIMATING PERCENT OF LOT WITHIN LIMITS (PWL)

Percent Within Limits (PL and PU)	Positive Values of Q (QL and QU)					
	n=3	n=4	n=5	n=6	n=7	n=8
99	1.1541	1.4700	1.6714	1.8008	1.8888	1.9520
98	1.1524	1.4400	1.6016	1.6982	1.7612	1.8053
97	1.1496	1.4100	1.5427	1.6181	1.6661	1.6993
96	1.1456	1.3800	1.4897	1.5497	1.5871	1.6127
95	1.1405	1.3500	1.4407	1.4887	1.5181	1.5381
94	1.1342	1.3200	1.3946	1.4329	1.4561	1.4716
93	1.1269	1.2900	1.3508	1.3810	1.3991	1.4112
92	1.1184	1.2600	1.3088	1.3323	1.3461	1.3554
91	1.1089	1.2300	1.2683	1.2860	1.2964	1.3032
90	1.0982	1.2000	1.2290	1.2419	1.2492	1.2541
89	1.0864	1.1700	1.1909	1.1995	1.2043	1.2075
88	1.0736	1.1400	1.1537	1.1587	1.1613	1.1630
87	1.0597	1.1100	1.1173	1.1191	1.1199	1.1204
86	1.0448	1.0800	1.0817	1.0808	1.0800	1.0794
85	1.0288	1.0500	1.0467	1.0435	1.0413	1.0399
84	1.0119	1.0200	1.0124	1.0071	1.0037	1.0015
83	0.9939	0.9900	0.9785	0.9715	0.9672	0.9643
82	0.9749	0.9600	0.9452	0.9367	0.9325	0.9281

Asphalt and Concrete PWL = Payment %

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96 – 100	106
90 – 95	PWL + 10
75 – 89	0.5PWL + 55
55 – 74	1.4PWL – 12
Below 55	Reject

501-8.1 PAYMENT. Payment for accepted concrete pavement shall be made at the contract unit price per square yard (square meter**)** adjusted in accordance with paragraph 501-8.1a, subject to the limitation that:

The total project payment for concrete pavement shall not exceed 105 percent of the product of the contract unit price and the total number of square yards (square meters) of concrete pavement used in the accepted work (See Note 2 under Table 3).

Payment shall be full compensation for all labor, materials, tools, equipment, and incidentals required to complete the work as specified herein and on the drawings, except for saw-cut grooving.

a. Basis of Adjusted Payment. The pay factor for each individual lot shall be calculated in accordance with Table 3. A pay factor shall be calculated for both flexural strength and thickness. The lot pay factor shall be the higher of the two values when calculations for both flexural strength and thickness are 100 percent or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either flexural strength or thickness is 100 percent or higher. The lot pay factor shall be the lower of the two values when calculations for both flexural strength and thickness are less than 100 percent.

Concrete PWL Calculation Example